APPENDIX D
SYSTEM PLANNER AND USER PERSPECTIVES

The 800 MHz Study assesses the relative merits of 800 MHz as an operating frequency band for public safety wireless communications and the extent to which 800 MHz operations has affected interoperability among systems at all levels of government. A requisite component of the assessment is cataloging the views and opinions of public safety officials who have contributed, at some level, to installing or operating an 800 MHz system. Additional valuable data were also obtained from public safety officials who have chosen to upgrade their public safety networks using systems at frequencies other than 800 MHz. The goal of Appendix D, System Planner and User Perspectives, is to understand, at a functional level, how 800 MHz systems have either improved or hindered interoperability, and how satisfied or dissatisfied users are with operations, system costs, and assignment and management of additional spectrum allocations.

Maintaining objectivity was as important as the information itself. Efforts were made attempting to obtain and include as many views as possible within the relatively short 3-month study period. Our objectives for this part of the study were to contact public safety officials, interview them about their current and planned land mobile radio (LMR) systems, and provide their comments and responses in an objective manner. Those efforts were achieved by the following –

- Creating a set of interview questions
- Compiling a list of possible interview participants
- Conducting six face-to-face interviews with several local public safety officials
- Conducting 22 telephone interviews with state and local public safety officials nationwide.

This "perspectives" portion of the 800 MHz Study is a *qualitative* assessment of public safety usage of 800 MHz spectrum. The data sample size is very small when compared with the entire public safety community. The interviewees responses, while germane, are indicative only of their individual thoughts and opinions concerning the specific questions asked during 1– to 2– hour interview sessions. The views of interviewees were their own and do not necessarily reflect the opinions of the public safety community as a whole or the city, county, or state government by which they are employed. The charts and percentages shown in the following sections are designed to show relative responses of the 28 participants. The study includes an adequate representation from a balanced group of participants in hopes that the concerns of most eligible public safety entities are addressed in the report.

Because of the short time frame available for interviews, certain biases were introduced into the study process. The first is the preponderance of participants in the Washington, DC, metropolitan area cities and counties. Over 20 percent of the participants were from this area of the country. Secondly, representation of non-800 MHz systems is limited to statewide systems.

Finally, only a small number of statewide systems were surveyed, and of those, few were considering 800 MHz systems. These biases prevent detailed analysis and may influence any conclusions about the entire nation. However, they do not prevent constructing a reasonable composite view of the effectiveness of 800 MHz systems from the data that have been collected.

D.1 Approach

The approach for this part of the study was to interview 800 MHz and non-800 MHz system planners and users about several issues relating to spectrum around 800 MHz as an operating frequency band for public safety.

D.1.1 Formulating Questions

A discussion guide was developed to ask general and specific questions important to understanding public safety's use of 800 MHz systems (i.e., operational impacts, system cost implications, optimal applications, and improvements to interoperability). A set of issues and questions was identified at the outset of the study and the following questions provided a basis from which the discussion guides were developed:

- What were the drivers for the decision to move to 800 MHz? Why 800 MHz?
- What is the effect on operations, coverage, and system costs?
- Assuming available spectrum, would agencies have remained in the very high frequency (VHF) or ultra high frequency (UHF) bands? Why?
- What effect did the switch to 800 MHz systems have on intra- or inter-jurisdiction interoperability?
- Has the migration to 800 MHz removed one of the barriers (i.e., spectrum) to achieving intra- or inter-jurisdiction interoperability?
- Are there other barriers to achieving intra- or inter-jurisdictional interoperability in the 800 MHz band? If so, what are they?
- How many radio channels were released with the migration to 800 MHz? From what portion of the spectrum? Was there a spectrum allocation plan? How was it structured? Why was the spectrum plan structured in this manner?
- Were radio channels from other parts of the spectrum retained? If so, from what part? Why were they retained?
- Are state and local governments assigning additional channels and talkgroups for intra- or interoperability? If so, how many? Why?

- Under what conditions is 800 MHz 'optimal' for public safety? Under what conditions is a different available band (e.g., UHF, VHF) 'optimal'?

- To what extent are the 800 MHz systems trunked systems? Conventional systems?

- Are trunked systems the preferred technology for public safety applications?

- Did or will 800 MHz systems cost more or less than the current systems in use? If so, what is the reason for the cost difference?

- Is 800 MHz right for public safety?

D.1.2 Obtaining Participation

Identifying possible participants was the first step in the interview process. The search for participants began through extensive use of available resources such as various industry-related documents, the World Wide Web, and database search engines (e.g., Lexis-Nexis and Proquest). The search enabled the acquisition of information on the implementation and purchase of 800 MHz communications systems by public safety entities. Using these data, a comprehensive list of possible interview participants was created.

Parallel to this process the Public Safety Wireless Network (PSWN) Program distributed a Participation Questionnaire to the public safety community. This questionnaire attempted to identify members of the public safety community willing to volunteer their time to participate in PSWN studies. When an analysis of the previously identified areas of interest and the responses received from the PSWN Participation Questionnaire was conducted, it became apparent that certain areas overlapped. Given the limited time frame for the study, the PSWN Participation Questionnaire respondents comprised the majority for 800 MHz study participants. A complete listing of agencies involved in the interviewing process of this study is included in the acknowledgements section of this report.

D.1.3 Measuring Balance

A critical element of the interview process was to survey a diversity of planners and users. This approach provided the most accurate view of all the variations and nuances that system planners and users face when considering upgrades to their radio systems. The interviewees were selected from a variety of categories primarily focusing on geographic dispersion, demographic dispersion, terrain, and system size and type. Figures D-1, D-2, and D-3 show a comprehensive view of the type of participant balance obtained statewide and locally. The remainder of the section analyzes these major categories to achieve the type of balance that was desired.

	Population (in Millions)			Square Mileage (in Thous.)			Terrain					Forestry			System						Vendor				
	10+	5-10	0-5	100+	50-100	0-50	Coast	Plains/ Flat	Rolling Hills	Mid - Mts.	Rocky Mts.	Barren	Deciduous Forest	Coniferous Forest	800 MHz	Other MHz	Analog	Digital	Trunked	Conv.	Motorola	Ericsson	EF Johnson	Lease	RFP
ska			●	●			●	●			●	●		●	●										
fornia	●			●			●	●			●	●		●		●	●			●					
orado			●	●				●			●	●		●	●			●	●		●				
ois	●				●			●	●			●	●												
a			●		●			●	●			●	●			●	●			●					
sas			●		●			●	●			●	●		●		●		●	●	●				
ntana			●	●				●			●	●		●		●		●	●						
State Patrol	●				●		●		●	●			●	●		●	●			●	●				
o	●				●			●	●				●												●
nsylvania	●					●			●	●			●	●	●				●						
th Carolina			●			●	●		●	●			●		●		●	●	●		●				
a			●		●			●			●	●		●											
State Patrol		●				●	●		●	●			●			●			●						
shington		●			●		●		●		●	●	●	●	●								●		
consin		●			●			●	●				●			●		●	●			●			

Figure D-1
Statewide System: Balance Matrix

	State	Population (in thousands)			Square Mileage			Terrain					Forestry			System						Vendor			
		500+	100-500	0-100	150+	75-150	0-75	Coast	Plains/ Flat	Rolling Hills	Mid - Mts.	Rocky Mts.	Barren	Deciduous Forest	Coniferous Forest	800 MHz	Other MHz	Analog	Digital	Trunked	Conv.	Motorola	Ericsson	EF Johnson	Lease
' York City	NY	●			●			●		●				●		●			●	●			●		
olk Co.	NY	●			●			●		●				●		●			●	●		●			
ıtgomery Co.	MD	●			●					●				●		●			●	●					
ce George's Co.	MD	●			●					●				●		●	●	●		●	●		●		
candria	VA		●				●	●		●				●		●			●	●		●			
ngton	VA		●				●			●				●		●			●	●		●			
ce William Co.	VA				●					●				●		●			●	●					
ngsville	OH															●		●			●		●		
ver, City of	CO								●	●			●			●		●		●			●		
ada	CO		●						●	●			●			●							●		
nge County	CA	●			●			●				●	●			●									
g County	WA	●			●			●		●	●			●	●	●	●	●		●		●		●	
kamas County	OR				●					●		●		●	●		●	●			●	●			
as	TX	●							●				●	●											
Worth, City of	TX				●				●				●	●		●		●		●		●			

Figure D-2
Local System: Balance Matrix

	State	Population (in thousands)			Square Mileage			Terrain					Forestry			System						Vendor			
		500+	100-500	0-100	150+	75-150	0-75	Coast	Plains/ Flat	Rolling Hills	Mid - Mts.	Rocky Mts.	Barren	Deciduous Forest	Coniferous Forest	800 MHz	Other MHz	Analog	Digital	Trunked	Conv.	Motorola	Ericsson	EF Johnson	Lease
ta	GA		●		●					●				●		●									
n County	NJ																								
ge Station, City	TX															●		●		●		●			
n County	NC																●	●			●				
on	TX	●			●				●				●	●											
Moines	IA		●			●			●	●				●		●			●				●		
	MO															●		●		●		●			
on	KS																●				●				
s City	MO															●		●	●	●			●		
Orleans	LA		●		●			●	●					●											
orage	AK		●		●								●		●	●				●					
-Phoenix	AZ	●			●				●				●			●	●	●			●				
ose	CA	●			●			●		●				●											

Figure D-3
Local System: Balance Matrix

Geographic Dispersion. The first critical factor in achieving balance was obtaining adequate samples of respondents nationwide. In such a large and diverse country, this factor is important because different geographic areas experience varying environmental conditions such as weather, terrain, and foliage, which can affect the propagation of radio waves, influencing their view of 800 MHz systems. Additionally, various political dynamics in different areas contribute to public safety entities opinions of 800 MHz systems.

Demographic Dispersion. A second important factor in achieving balance was interviewing in areas with varying population and square mileage to cover. Population is directly related to system size and the complexity of the public safety mission. For statewide systems, the interviews surveyed areas in three population categories:

- Greater than 10 million people
- Between 5 and 10 million people
- Below 5 million people.

For local and county systems, the population areas were also divided into three groups:

- Greater than 500,000
- Between 100,000 and 500,000
- Less than 100,000.

The coverage area of the system is also an important factor in measuring balance. The interviewees were selected from several different size coverage areas because this factor dramatically affects not only the system architecture but also system costs. Again, the three distinct categories for size of states were as follows:

- Greater than 100,000 square miles
- Between 50,000 and 100,000 square miles
- Less than 50,000 square miles.

For local and county entities, coverage requirements were categorized as follows:

- Greater than 150 square miles
- Between 75 and 150 square miles
- Fewer than 75 square miles.

Terrain. Terrain can affect signal propagation and drive, in part, the selected frequency band of systems installed. It was important to interview participants located in a variety of terrain to understand their views on which systems perform better in specific environments. The terrain for state and local systems was divided into five distinct categories:

- Coastal
- Plains/flatlands

- Rolling hills
- Mid-mountain regions (such as Appalachian sized mountains)
- Rocky Mountain regions.

Additionally, forestation is an important factor in terrain. Deciduous and coniferous trees have different effects on various radio signals. These effects make it extremely important to capture responses from areas with varying forestation. For both state and local systems, forestation was divided into three categories: barren, deciduous forest, and coniferous forest.

System Dynamics. A final critical factor used to measure the balance of the interviews was system dynamics. It is important to obtain a good cross section of statewide systems and local systems. Because of the high concentration of public safety services and systems at the local level, it was deemed reasonable to interview more people at the local level than at the state level.

To understand 800 MHz system issues, it is critical to have representative input from both "general service" 800 MHz systems and National Public Safety Planning Advisory Committee (NPSPAC) 800 MHz systems. It is also important to understand the issues of public safety systems operating in various bands and the reasons certain system designers did not choose to move to 800 MHz. The interviewees represent members from each of these categories as well as those who are operating on lower band systems but are in the process of migrating to 800 MHz systems.

Vendors. One added factor at the system level is the use of different equipment vendors. It was critical to identify and question users of a variety of vendor equipment. The category was divided into the three major radio system vendors: Motorola, Ericsson, and E.F. Johnson. The team attempted to include systems for each of these vendors. In some instances, systems could not be categorized by vendor in this way. In these cases, most systems were in one of two situations: either the system is the subject of an active solicitation and the vendor is not yet known, or the system or its service is leased from a commercial service provider.

D.1.4 Conducting Interviews

An interview guide was developed to assure that each interview was conducted in a similar fashion. As discussed earlier, this guide contained a series of questions developed to focus interviews on the issues that the 800 MHz Study was trying to examine. Although the interview guide was used to direct the flow of conversation, interviewees generally provided additional information on a variety of topics.

Face-to-Face Interviews. Six interviews were conducted in the Washington, DC, area. Because of the proximity of Washington, DC metropolitan area public safety entities, six interviews were conducted in person. Each interview consisted of two to three Booz·Allen staff who interviewed representatives from local city and county public safety entities.

Phone Interviews. The remaining 22 interviews were conducted via telephone. These phone interviews occurred at scheduled times and averaged 1 hour in length. Each phone interview

consisted of two to three Booz·Allen staff who interviewed representatives from various public safety entities nationwide.

D.1.5 Analyzing Responses

Once the interviews were completed, it was imperative to develop efficient mechanisms for analyzing the collected data. Two strategies were implemented to capture the unique responses from each interview, interview notes and an interview comparison matrix. The following paragraphs briefly describe these tools and the methods of assuring accuracy of analysis.

Interview Notes. After the interviews were completed, the responses were collated into interview packets. The interview team double-checked the results for accuracy and then used those results for analysis. The interview notes were used as the major repository of unique comments captured from the interviews as well as a means to effectively relay the discussion to team members who could not attend an interview.

Interview Comparison Matrix. The interview criteria matrix tool was used to compare and contrast all interview responses. Common answers were compared using a matrix format that allowed for all responses to be placed side by side to assess similarities and differences. The tool compared the responses of planned systems to implemented systems, 800 MHz systems to non-800 MHz systems, as well as responses from regional, state, county, and local interviewees. These divisions helped display specific trends across the various categories.

D.2 Overview of Perspectives

The previous sections outlined the process that was followed to capture and analyze perspectives of system planners and users. In the following sections, this analysis is more formally structured into three sections. The first deals with the perspectives regarding the regional planning process. This section provides discussion points concerning the effectiveness of the regional planning process employed for the allocation of the 821–824/866–869 MHz band. The second section chronicles many of the suggestions system planners and users cited as possible improvements to the regional planning process. The third section deals with technical issues of concern to those migrating to 800 MHz systems. This section covers issues such as spectrum usage, interoperability, coverage, vendor technology, as well as several other topics of interest.

D.3 Planning Process Perspectives

Several interview guide questions concerned the national planning and regional planning processes. The following sections discuss the interview participants' responses to these questions.

D.3.1 Regional Planning Effectiveness

To evaluate the effectiveness of the planning process established by the National Plan, participants were asked to rate their regional plan as a tool for achieving systems interoperability. Four ratings were given: very effective, effective, minimally effective, or unused. Figure D-4 illustrates the responses of the participants.

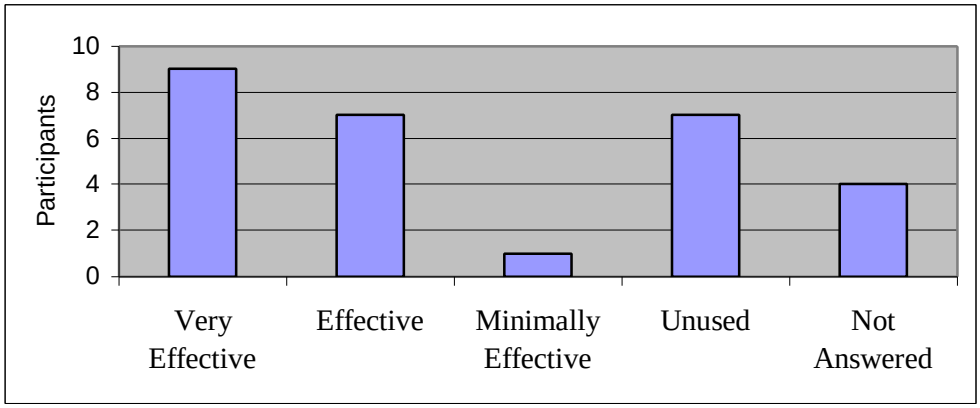

Figure D-4
Rated Effectiveness of Regional Plans

Very Effective. Participants who selected this rating thought that regional plans were very effective in meeting the spectrum needs of all affected public safety entities. The interview participants noted several common attributes associated with an effective regional plan despite their dissimilar system requirements. The following interview excerpts identify common attributes of an effective regional plan:

- The regional plan worked well because it envisioned solving the problems of the public safety community. As a tool for promoting interoperability at the national and regional levels, the regional plans acknowledged the urgency of addressing and solving the problems of public safety communications.

- A NPSPAC frequency user stated that because of the lack of available general pool channels, many frequency-starved areas found spectrum relief by obtaining frequencies through the regional planning process.

- The regional planning committee worked well as the "gatekeeper" of frequencies. Meeting continuously throughout the months, the regional planning committees overcame parochial needs to fairly assign frequencies in their regions.

- A user indicated that the influence of the Council of Governments (COG) in their region greatly increased the effectiveness of the corresponding regional plan. Because COG actively addressed public safety issues in this area, a strong working relationship with all local jurisdictions had already been established. This relationship facilitated

efforts among the region's public safety entities to address the issues plaguing public safety communications systems.

- One participant stated that developing the regional plan was virtually painless. The template[1] sufficiently addressed all topics and streamlined the entire process allowing the region to quickly and thoroughly complete the regional plan and submit it for approval.

Effective. Although some participants were pleased with the effectiveness of the regional plans, others were reluctant to claim the regional plans were very effective. Many participants stated the idea of the plans are "sound" but were critical of plan implementation. The following interview excerpts identify some of the flaws in the implementation of the planning process:

- A regional planning committee member in a highly congested area stated most regional planning committee participants came mainly from large jurisdictions with many users. The interviewee indicated certain public safety entities are under- represented on the regional committees[2] and 75 percent of the public safety agencies located in the region are composed of fewer than 25 officers and therefore were not involved. The unbalanced participation between large and small public safety entities demonstrates that although some areas benefit from the planning process, others do not.

- Another participant stated that although the regional plan was an effective planning tool, it has not improved interoperability, nor will it in the next 3 to 5 years. This participant claimed that the plans address only immediate communications needs and fail to address long-term issues.

Minimally Effective and Unused. This grouping consisted of three displeased 800 MHz users and all of the non-800 MHz users. These participants believed that in each case, the plans ineffectively addressed the needs of affected agencies. The following comments depict reasons the plan was viewed as minimally effective or unused:

- A participant stated the regional planning committee was ineffective because of its inability to reassign unused spectrum to more frequency "starved" areas within the region.

- A state agency participant thought the plans responded only to the voice of local entities and limited the involvement of state entities. The participant indicated that local groups working on these problems focused on immediate spectrum relief only and not on long-term improvements such as interoperability.

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1 The Association of Public-Safety Communications Officials International, Inc. (APCO) created a standardized regional plan to expedite the regional planning process. The standard plan was used by a significant number of the 55 regions.

2 To meet public safety communications needs, the National Plan mandates regional planning committee memberships be open to representatives from all eligible public safety user groups, including governmental and non-governmental. Although participation is required, the FCC made no efforts to assure that robust participation was achieved.

- A common complaint is the involvement, both past and current, of regional planning committees. Although the committees still exist, many have had no substantial actions or have been rendered inactive.

D.3.2 User Recommendations To Improve the Planning Process

Participants were asked to make suggestions on how to improve the effectiveness of the national and regional planning process. Regardless of their level of support for the planning process, participants were quick to make suggestions. The ideas presented below are not necessarily opinions of all participants but reflect both common and unique themes stated throughout the span of all the interviews:

- Most participants stated involvement of the public safety community is essential to the planning process. The participation of all affected entities (local, state, and federal) is imperative to achieve common goals within the public safety community. Based on survey results, if one were to create an ideal committee, it would include a complete representation of federal, state, county, and city participants.

- Another common suggestion was to identify a significant source of funding for support of the regional planning committees. Advocates of funding believe that financial support will promote the involvement of many local entities that previously could not afford travel expenses. These funds would also pay for reproduction costs, postage, and other miscellaneous items.

- Approximately one-half of the participants criticized the FCC's ineffectiveness in dealing with regional needs. Examples of the problems included the slow response to pending decisions and regional disputes. The participants suggested that the FCC define more specific rules and guidelines at the national and regional levels as well as expeditiously address and resolve any regional issues that arise.

- Many participants advocated the idea of a neutral oversight committee. This committee was described as a limited policy-making authority, composed of technical and political representatives from various levels of government, strictly facilitating discussions and overseeing action toward reaching a common national goal. Another possible role for such a committee was portrayed as a coordinator between federal and non-federal resources. For example, the coordinator could identify unused federal resources for potential public safety use.

- Several participants stated inter-regional coordination needed further attention. Whether through the FCC, a neutral oversight committee, or another entity, increased coordination among regions must improve to achieve efficient inter-regional communications.

- Two participants claimed the biggest improvement to the process would be to make the APCO/CET frequency-sorting program[3] more realistic and catered to specific geographies and needs.

D.4 Technical Issues Perspectives

Several questions contained in the interview guide concerned the technical aspects of 800 MHz systems as understood by the system planners and users. The following sections discuss the interview participants' responses to these questions.

D.4.1 Spectrum Usage

Throughout the Nation, public safety radio communications reside in multiple frequency bands within VHF, low-band UHF, and 800 MHz. Members of the public safety community have varying opinions about which frequency band best suits their communications needs. Table D-1 shows that although some agencies are migrating or planing to migrate to 800 MHz as an operating frequency band, others have chosen to remain at VHF and other UHF frequency bands. Therefore, to assess the relative merits of 800 MHz as an operating frequency band, it is necessary to consider the reasons for operating at frequencies within the VHF, UHF, or 800 MHz frequency bands. This section highlights responses demonstrating the merits of these different frequency bands.

Table D-1
Interviewee Operating Frequency Bands

Band of Operation	Number of Agencies*
VHF	4
UHF	2
800 MHz	24
*Includes implemented and planned systems	

VHF. The reasons that the VHF band is still considered viable spectrum for public safety are threefold: the significant amount of embedded infrastructure at VHF, the advantages of low-frequency propagation characteristics, and the newly realized ability to trunk at VHF. Most, if not all, participants who stated that VHF was the ideal band were currently operating in that band and had decided not to move, or were hesitant about their upcoming move to 800 MHz. These same participants also tended to advocate a specific means for determining the usage on government and military frequencies in that range, and if frequencies were found unused, establishing a quick mechanism to reallocate them to public safety. The following excerpts present opinions on why some feel VHF best suits public safety communications.

[3] The APCO/CET frequency packing program assigns frequencies to specific public safety eligibles and to pools for future assignments. This program is designed to result in a high degree of spectrum efficiency and low probabilities of interference. Analysis of the regional plans indicates that 84% of the regional planning committees used this program to assign frequency.

- An administrator from a large western state indicated the state would stay in the VHF range because trunking and digital capabilities are available in this band[4], allowing nearly all the same features of an 800 MHz system.

- Many agencies have a significant embedded infrastructure that meets the needs of the agencies' specified mission. To move bands, they would have to engineer the new systems to be backward compatible with existing systems. Because the existing systems are deeply embedded, there is no compelling reason to move.

- A representative of a large state police agency suggested that the optimal frequency would be wherever the military operates because "chances are they use all of the good frequencies." The participant continued by stating that the worst public safety spectrum would be in the frequencies where no one is licensed, such as around 800 MHz.

Low-Band UHF. To some, low-band UHF is seen as the best compromise among all public safety spectrum. Although several interviewees identified this band as the optimal spectrum for public safety, few interviewees gave any details or compelling support for use of this spectrum. The following responses capture the benefits of the UHF band.

- A system manager of a large county stated the county currently operates on UHF T-band channels (470-512 MHz). These T-band channels suit public safety communications because only 13 of the largest metropolitan areas across the nation were granted licenses on these channels.[5] Because there are few licensees, channel interference on the T-band channels is less than the interference present at other frequency bands. In general, channel interference is correlated to spectrum traffic capacity. As traffic on the public safety spectrum increases, channel interference also increases.

- In many markets, only 3 to 10 broadcast television channels are being used, leaving several allocated channels unused. These unused channels are located in the UHF band near current public safety frequencies. If available, these channels would be prime spectrum for public safety use, offering many systems planners a powerful reason not to migrate to 800 MHz.

800 MHz. The lack of spectrum in VHF and low-band UHF, coupled with the availability of spectrum designated for public safety use in the 800 MHz band was commonly cited as a reason driving public safety communications to the 800 MHz band. Many participants claimed that over the past several years, radio communications traffic has grown faster than expected. Because

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[4] On February 20, 1997, the FCC adopted *Second Report and Order* (FCC 97-61), allowing centralized trunking in the 150-174 MHz, 421-430 MHz, 450-470 MHz, and 470-512 MHz frequency ranges. The *R&O* was implemented on October 17, 1997.

[5] T-Band channels can only be used in 11 of these 13 areas. Cleveland, OH and Detroit, MI have active licenses but are not allowed to use the channels until further notice from the FCC.

current radio systems were not originally designed to support the unexpected surge in public safety radio communications, many systems have become overcrowded and overloaded.

Regardless of the system size or geographic location, a majority of interviewees indicated spectrum-related issues such as interference and availability factors affected their decisions to migrate to 800 MHz. The following excerpts from interview participants give unique insight into the impact of spectrum availability on the migration to 800 MHz.

- A state radio planner was trying to expand his system in the VHF range, however, because of heavy congestion in the state's most densely populated corridor, the planner was unable to obtain additional VHF frequencies. After a failed attempt to develop a new frequency plan, the state decided to pursue an 800 MHz system.

- A county communications director, whose jurisdiction is adjacent to a major metropolitan area, was extremely critical of the 800 MHz band, specifically because of the propagation effects through areas of dense foliage. Although the frequency band is not optimal for use in this area, the agency is still planning to migrate to 800 MHz because it is available.

- A county radio manager whose operational jurisdiction borders Canada expressed concern about the lack of spectrum in any band. Treaties force the county to split frequency assignments with jurisdictions across the border. To alleviate the frequency crunch, the county is choosing to move to an 800 MHz system. Although frequencies will still have to be shared, interference problems will be lessened as a result of the reduced radio traffic in the 800 MHz bands.

Vacated Channels. The availability of frequencies to support the needs of public safety communications is a constant concern of public safety officials. As previously mentioned, the availability of spectrum to expand current radio systems in VHF and low-band UHF is scarce. To alleviate the spectrum congestion in the lower bands, the FCC included a provision within the *Report and Order in the Matter of Development and Implementation of a Public Safety National Plan and Amendment of Part 90 to Establish Service Rules and Technical Standards for Use of the 821-824/866-869 MHz Bands by the Public Safety Services (National Plan R&O)* of the National Plan to address the issue. Public safety radio system managers who migrate to the 800 MHz bands via the national planning process and operate on the NPSPAC channels are required by the National Plan, with some exceptions, to release their vacated frequencies for reassignment. This begs the question: are public safety entities complying with this provision and returning frequencies? If not, how are the vacated frequencies being used? To begin to answer these questions, the interview participants were asked two questions:

- What happened to the frequencies at which you were previously operating?
- Are you still using this spectrum?

Respondents fell into three categories: agencies that gave back all previously used frequencies, agencies that gave back some previously used frequencies, and agencies that did not give back any previously used frequencies. These categories are provided in Table D-2.

Table D-2
Frequency "Give Back" Activity

Amount of Frequencies Given Back	Percentage of Agencies (%)
All	18
Some	54
None	7
Unanswered	21

Agencies that claim to have given or plan to give back all previous operating frequencies thought that the new 800 MHz systems would sufficiently support their communications needs. For these respondents, available frequencies are plentiful, eliminating any need to retain frequencies for additional use. The following examples of comments depict the willingness of these entities to return their frequencies to the Commission:

- A system administrator operating on the general service channels indicated that his agency is attempting to give back its old frequencies, but nobody in the area really needs or wants them.

- A director of communications whose radio system is migrating to the NPSPAC channels stated that after the migration is complete, all agencies will be operating on one system and no additional channels will be needed. Therefore, the frequencies will be given back as mandated by the National Plan.

A majority of 800 MHz users have given back some of their previously used frequencies to the Commission but continue to use the remainder. Because these systems are located in highly congested and frequency-starved areas, the retention of some frequencies is necessary to support the growing need for public safety communications. For NPSPAC frequency users, the lack of available new spectrum has meant retaining previously used frequencies instead of abiding by the provision within the National Plan mandating the return of previously used frequencies. Because of the need for additional channels, both general pool and NPSPAC system users generally continue to use their retained frequencies. The following excerpts convey participants' reasoning concerning retaining previously used frequencies and the uses that these retained frequencies serve:

- A system manager of a large city's congested communications system operating on general pool frequencies stated that all but five previously used VHF channels had been returned to the FCC. The other channels were retained to support the increasing needs of public safety communications and were split among fire, law enforcement, and local mutual aid.

- A manager of a large, frequency-starved county migrating to the 800 MHz band indicated that because not enough channels are available in the NPSPAC band, current operating channels will be retained for data communications.

- Other NPSPAC system users stated that to remain interoperable with adjacent public safety entities using non-800 MHz frequencies, a few frequencies were kept for mutual aid communications.

Few participants retained all previous channels. In each case, the respondents stated that these channels were being reserved to support future needs of public safety communications. The following comment eloquently states the reasoning behind retaining all previously used frequencies:

- Two managers of congested county communications systems stated that because they are operating on the general pool channels, the counties have no obligation to give previously used frequencies back. As a result, both areas are holding their previously used frequencies for future purposes.

D.4.2 Interoperability

Interoperability of radio communications systems is a critical issue within the public safety community and the primary concern of the PSWN Program. Because of the importance of this issue, a series of questions were developed to ask system users and planners to address the extent to which 800 MHz systems have affected the interoperability issue. The questions are divided into two distinct sections: "Achieving Interoperability," which addresses how interoperability is accomplished as entities migrate to 800 MHz systems, and "Influencing Interoperability," which addresses the factors affecting interoperability (both positively and negatively).

Achieving Interoperability. During the interviews, respondents discussed how interoperability was achieved before implementation of the new 800 MHz systems. Most reported that there was either limited or no interoperability among entities within their jurisdictions. The majority stated that police and fire departments operated on separate systems and achieved interoperability through the exchange of spare radios. Interoperability with adjacent jurisdictions and federal or state agencies was also realized through radio swapping. In some instances, though, jurisdictions did use a radio console patching capability that allowed a limited talk capability between agencies.

Table D-3 depicts the different methods by which public safety agencies achieved interoperability following the implementation of 800 MHz systems. Many of the respondents using 800 MHz trunked systems indicated that they achieved intra-jurisdictional interoperability by using dedicated or as-needed mutual aid talk groups. If adjacent jurisdictions are also using 800 MHz trunked systems, inter-jurisdictional interoperability is also achieved using talk groups. Those entities that use 800 MHz conventional systems or non-800 MHz systems generally achieve interoperability through cross patching, radio swapping, and the localized use of mutual aid channels. Interoperability with federal entities continues to be achieved mainly by radio swapping. Several respondents stated that the Federal Government has provided no guidance on

interoperability requirements; therefore, respondents continue to purchase systems that work well for their jurisdictions and have not focused on interoperability with federal entities.

Table D-3
Common Methods for Local Agencies To Achieve Interoperability

Method	With Agencies in Own Jurisdiction	With Agencies in Adjacent Jurisdictions	With Federal Agencies
Common Talk groups	√	√	
NPSPAC Mutual Aid		√	
Cross-Patching	√	√	
Phone			
Voice Through Dispatch		√	
Radio Swapping	√	√	√
Monitor Other Frequencies	√	√	√
State and Local Mutual Aid Channels	√	√	√

The following comments offer insight into the different ways jurisdictions achieve interoperable communications:

- A radio manager from a small city indicated that the city has a dedicated talk group for interoperable communications. A cross-connection links this dedicated talk group to the county sheriff's VHF channel.

- An administrator of a small metropolitan county stated that, as a part of the county's system procurement, spare radios were purchased to issue to federal agencies such as the Federal Bureau of Investigation (FBI) and Drug Enforcement Administration (DEA) on an as–needed basis.

- A system planner of a large county indicated that the county interoperates with adjacent jurisdictions through a multi-channel local mutual aid system.

- A city representative commented that the local low-band UHF mutual aid channel was very effective, and the city had no plan to vacate its use.

Influencing Interoperability. Using 800 MHz does not inherently improve interoperability. There are, however, capabilities routinely and predominantly found and implemented at 800 MHz that have had an influence on interoperability. The use of trunking technology, and the availability and use of the NPSPAC mutual aid channels at 800 MHz, have had significant effects on interoperability. These effects, both positive and negative, are discussed below.

Interoperability Improvements Created by the Use of Trunking Technology. The primary benefit of trunking technology is that it allows reuse of spectrum resulting in a spectrally efficient system.

In addition to providing improved spectral efficiency, trunking technology allows the development of talk groups. Such talk groups provide virtual independent networks for specific user groups and a means for intra- and inter-jurisdictional communications that was previously unavailable. Overall, interoperability has improved with the implementation of 800 MHz trunked systems. The following reflections provide evidence of the positive effects of trunking on interoperability:

- One county representative stated that improvements in interoperability were related not so much to the move to 800 MHz but to the technological and operational improvements offered by trunking, which is a readily available system architecture option at 800 MHz.

- A city communications director consolidated 27 individual radio systems into a single 800 MHz trunked system, which led to improvements in intra-jurisdictional interoperability, reliability, coverage, and operations.

- A radio manager of a suburban area indicated the decisions to implement an 800 MHz system and to select a specific vendor were influenced significantly by the systems and vendor decisions that had been made in the neighboring jurisdictions of the metropolitan area. The radio manager indicated the suburban area wanted to maximize the degree of interoperability with its nearest neighbors and made system design and vendor decisions accordingly.

- A communications manager for a smaller city, whose jurisdiction is adjacent to larger counties, selected 800 MHz primarily because the larger counties had successfully tested and implemented an 800 MHz system, and the smaller city wanted to "piggyback" off the larger system to achieve interoperability.

Interoperability Impairments Created by the Use of Trunking Technology. From the interviews, the greatest impairment to interoperability appears to be incompatibility with neighboring jurisdictions. Participants stated that different vendor trunking technologies lead to incompatibility among 800 MHz trunked systems, which diminishes interoperability. In most cases, respondents said that the absence of a technical standard for trunking technology has had an adverse effect on interoperability.[6] The following comment provides insight into this problematic issue:

- A metropolitan area had significant interoperability problems because half of the cities and counties had chosen the equipment of one of the major vendors, while the remaining cities and counties had primarily selected the products of other vendors. In some cases, cities had chosen different vendors than the counties in which those cities were located, resulting in incompatible systems and further impediments to interoperability.

[6] Each major LMR vendor has its own signal processing scheme for implementing trunked networks.

Interoperability Improvements Created by the Use of the NPSPAC Mutual Aid Channels. In addition to trunking, the five NPSPAC mutual aid channels have added another means for achieving interoperable communications. The NPSPAC regional plans contain guidelines for the operational use of the five NPSPAC mutual aid channels, which have been allocated specifically to promote public safety interoperability. The extent to which these mutual aid channels have enabled interoperability is a function of how effective the respective regional plans were in laying out a governing framework and how diligent system implementers have been in building out the mutual aid capability.

As a measure of the impact that the regional plans have had on facilitating interoperability, participants were asked to comment on their familiarity with the NPSPAC mutual aid channels and their role, if applicable. None of the survey respondents were able to seamlessly interoperate with federal agencies on the NPSPAC mutual aid channels. They said that federal radios do not operate in the 800 MHz range and were therefore incompatible with their systems. Interoperability with federal users was achieved by swapping radios. The following are reflections regarding the use of the NPSPAC mutual aid channels on implemented 800 MHz systems:

- One county planner said that the five NPSPAC mutual aid channels are used as specified by the National Plan. The county follows the established procedures set by the regional plan, and interagency communication has been effectively accomplished during disaster situations.

- A respondent indicated that because of different vendor trunking technologies deployed in adjacent jurisdictions, the conventional NPSPAC mutual aid channels are the only means of interoperability. Because all efforts to patch together differing systems have failed, there is extensive use of the NPSPAC mutual aid channels to coordinate efforts among neighboring systems.

- A Washington, DC, respondent indicated that the metropolitan COG has assigned six channels solely for mutual aid by its members in addition to the NPSPAC mutual aid channels. These additional channels are intended to enhance mutual aid efforts throughout the metropolitan area.

Interoperability Impairments Created by the Use of the NPSPAC Mutual Aid Channels. Not all public safety entities capable of using the NPSPAC mutual aid channels have experienced an improvement in interoperability. The following comments address some of the inefficiencies attributed to the NPSPAC mutual aid channels:

- One system planner stated that even though the channels are technically working, operationally they seem nonexistent. He claimed that the NPSPAC mutual aid channels are monitored regularly, but no communications have ever been heard.

- Two respondents stated that although the NPSPAC mutual aid channels are monitored constantly, a call has never occurred on the channels, and the channels have never been used for mutual aid purposes.

- One radio manager of a large city attributed the limited use of these channels to funding issues. This person indicated that implementing the channels within local systems requires additional expensive equipment (e.g., repeaters) for which funding is uncertain or unidentified.

To overcome these impairments, participants planning new 800 MHz systems were projecting the use of the NPSPAC mutual aid channels in the new system. In each case, the participants indicated that plans are under way to use the NPSPAC mutual aid channels to support the increased communications needs between various public safety entities. From this observation, it seems that as the need for interoperability increases, many system planners are now implementing the NPSPAC mutual aid channels within their new systems.

Interoperability Impairments Created by Other Factors. The interviewees identified several other factors that have hampered interoperability. These factors include the following: system incompatibility, lack of spectrum, operational and political issues, and deviation from the regional plan.

In addition to system incompatibility, which was discussed earlier, other problems attributable to operational and political issues were identified. Several respondents stated that "egos" and "turf battles" between departments and jurisdictions were a stumbling block to developing an interoperable system. Differences in operational procedures between fire and police departments have caused splits in systems, deepening the technology barrier with respect to interoperability. Additionally, the move to 800 MHz further segregated an already splintered public safety spectrum. The following comments address these factors identified as impairing interoperability:

- A planner for a large county indicated that "ego" and long-standing personal opinions of managers have led to systems designed along strict jurisdictional boundaries, hampering interoperability.

- An administrator for a large county indicated that he was concerned about a move to 800 MHz in part because the entities moving would lose interoperability with the entities remaining in the VHF band.

D.4.3 Technical Capabilities

Most interviewees expressed concerns regarding the technological capabilities of 800 MHz systems when they were planning the acquisition and implementation of these systems. During the planning and design stages, system managers had serious concern, regarding the performance of the new systems. In retrospect, however, they have realized that many, if not all, of these concerns were unfounded or at least overstated. They now view the technical features of 800 MHz systems as clear benefits and, if they were now back in the planning stages, would view the technical capabilities as a positive driver for selecting an 800 MHz system.

Data Transmission. The ability to realize higher data transmission rates at 800 MHz is one of the attractive technical capabilities mentioned by most participants. Data transmission is needed to support increasing mobile data requirements, or at a minimum, provide entities with an ability to support their own data networks rather than lease from vendors. Many mobile data applications are supported at 800 MHz because of the amount of spectrum available here and because the channel widths have been defined and implemented. The following thoughts provided by interview participants concern the use of data transmission at 800 MHz:

- A police chief in a mid-size city in the process of planning a system indicated that if the city were to implement an 800 MHz trunked system, it could eliminate the monthly $80 to $90 per unit charge for mobile data service.

- A state communications manager indicated the wide bandwidth of channels[7] at 800 MHz allows the state to implement many data applications.

Trunked Technology. Trunking technology allows simultaneous use of several channels within a given system. The computer-controlled system automatically assigns available channels to different talk groups, thereby maximizing the use of the available channels. With more channels available, users are far less likely to experience a channel "not-available" condition. Several respondents stated that their systems almost never experience conditions where all channels are busy. They stated the time saved by not having to wait for a clear channel has increased productivity and greatly improved law enforcement operations.

Trunking technology has greatly increased the channel availability to the users. This, coupled with the development of talk groups for specific user groups, has greatly improved interoperability within jurisdictions. Formerly, the technology was only available in the 800 MHz frequency band. However, in 1997 the FCC adopted FCC 97-61, which allows the use of trunking in lower frequency bands. Therefore, many system planners are assessing the ability to trunk their current VHF or low-band UHF systems rather than migrate to 800 MHz. This indicates strong support for trunking technology and its capabilities.

Perspectives of Trunking Technology. From interview results, the use of trunked 800 MHz systems seems widespread throughout the Nation. Of all the respondents who have moved to or planning to move to 800 MHz, all but two claimed to be using a trunked system. Among the reasons for trunking are that it allows for better and more efficient use of channels, enables operational efficiencies, decreases access times to open channels, and encourages greater integration among systems. Radio communications systems developers are realizing the utility of shared resource schemes such as channel trunking. The benefits they are realizing are analogous to those gained by public switched network managers after they began building access lines into trunked cables and started offering "bandwidth on demand" virtual circuits between points on a network.

[7] The NPSPAC channels allow a 25 kHz channel bandwidth. The FCC has adopted regulations that impose narrowband channel requirements on public safety radio equipment for bands below 512 MHz. These regulations apply only to new equipment, not legacy equipment.

Among participants with implemented 800 MHz systems, there was a nearly unanimous view that trunking was the preferred technology. Only a small percentage disagreed, taking the more cautious approach that trunking preferences primarily depend on agency or area specific requirements. The following comments reflect some common thoughts on trunking preferences:

- A system administrator indicated that trunking is a smart design choice irrespective of system size.

- Another administrator said trunking is also preferable for jurisdictions seeking to reduce costs by merging different operations and still meet the mission of each agency.

- One agency representative felt that if enough frequencies were available, the agency would stay conventional; however, a trunked system would be implemented to stretch spectrum resources through channel reuse.

- One radio system planner indicated that trunking is preferable but significant planning and coverage testing is required before implementation to ensure proper configuration of the trunked system.

Included in the discussion of trunking technology was the idea of regulating trunked systems for public safety communications systems. Most people, including radio system planners, were leery of any government regulation. Radio systems have a wide variety of qualities: geography, weather, forestation, system size, coverage area, and radio service mission. Because all of these qualities contribute to defining the essential characteristics of a radio system, it would be very difficult to develop one all-encompassing standard for trunking regulations. Many differing opinions were stated, but two main issues were discussed in regard to government regulation of trunking: regulated trunking requirements on public safety radio systems, and trunking technology standards that would allow for an open architecture.

Perspectives on Mandated Trunking. Analysis of the comments from those participants who felt there should not be a government regulation on trunking shows their primary concern is that there is no "standard" radio system; each peculiarity should be examined on an individual basis. Most pointed to the fact that although trunking is beneficial, and perhaps should be regulated in large, frequency-starved metropolitan areas, trunking is not necessary, and should not be forced on smaller systems that have no need for trunking and no frequency crunch.

Most felt that if a trunking regulation is developed, the Government must allow sufficient time for system planning. Additionally, there would have to be a funding source to assist those who are forced to migrate and those who would never migrate without legislation. Some participants thought that trunking should be regulated, regardless of the frequency band of operation. The respondent added, however, that funding such an initiative would be critical. The following selected comments show the variety of views on governmental trunking mandates:

- One user suggested that the FCC should allocate adequate spectrum for public safety so that system planners would have an adequate number of channels to implement trunking technology regardless of the frequency band of operation.

- A radio manager for a metropolitan suburb indicated the need for public safety to have a mandated trunking standard because it would allow governments to serve their jurisdictions more effectively.

- Trunking should be mandated or, at a minimum, the FCC should regulate spectrally efficient technology regardless of the frequency band.

- Another user emphasized the necessity to leave a way out of the regulation by offering loopholes to those who will use alternate spectrally efficient technologies.

Trunking Standards. If trunking is to be mandated on a governmentwide basis, the participants indicated that a trunking standard must be developed. Many of the concerns regarding interoperability focused on the need for a standardized architecture, the lack of which stems specifically from differing vendor trunking technologies. Several respondents pointed to television and computer manufacturers that developed standards making their equipment interoperable with that of other manufacturers' equipment. Because LMR users do not have the advantage of standardized systems, they feel that once they select a vendor, there is no more product competition.

Not all the participants shared this view. Some were less receptive to the idea of a trunking standard because they felt it would slow down the technological progress and inhibit new development in LMR. Some groups pointed to Project 25 as a basis for a nationwide trunking standard. The following comments were made concerning the development of standards for trunking and open architecture:

- A trunking standard should be developed that does not favor a specific vendor. Such a standard would allow for multivendor radio systems, improvement in interoperability, and reduction in the cost of radio equipment.

- A large state supports the work of Project 25 and feels that it has the greatest potential of becoming an adopted standard.

- A nationally supported standard would be preferable, but it could effectively force entities to use a specific technology that may in turn limit or preclude future technical progress.

D.4.4 Influence of Vendor Technology

Demand focuses on technologies that promote interoperability and spectral efficiency. To satisfy the demand for new communications systems, vendor technology has followed suit. Several participants commenting on this issue noted that because vendor

technology, research, and development is primarily focused on 800 MHz, most innovations have come and will continue to be made in technology for resources in this frequency band. Additionally, with the vendors spending a preponderance of their resources on 800 MHz technology to the exclusion of VHF and low-band UHF technologies, many system users and administrators are concerned about the sustainability and continued viability of current VHF or low-band UHF radio technologies. Many participants hinted that to remain current with technology, the transition to an 800 MHz radio system is imperative. The following examples offer evidence that users are aware of, and driven by, the direction of vendor technology:

- A manager of a populated county system stated that because vendor research and development is primarily directed toward 800 MHz technology, any move away from this apparent mainstream would lead to higher costs for that county's radio system and greater isolation in the marketplace.

- A communications director from a small county expressed the need to implement a system that was at the forefront or at least on par with LMR technology advances.

For some entities, the influence of vendor technology on the decision to move to 800 MHz was not seen as a point of pressure but as a fortuitous development. These respondents realized that their systems were aging. System maintenance required a significant and often increasing expenditure. Many users believed that it would be nearly as cost effective to implement new systems as to try to maintain their old systems. The advances by vendors in the 800 MHz marketplace support such decisions. The following comment is an example of how system age is affecting public safety radio systems:

- A state radio manager commented the state is operating 15 to 25-year-old radio equipment. Additionally, they have more than 500 unique tower sites, many of which are deteriorating and in need of serious repair or replacement. Because the system costs are already high and the system needs to be replaced, the state is more willing to face the costs of a new state-of-the-art radio system in the 800 MHz band. In addition, the manager noted that a lack of available frequencies in lower bands was a factor driving him to look at 800 MHz.

D.4.5 Coverage

Coverage is a contentious issue for 800 MHz implementations. Nearly all the respondents indicated that problems with 800 MHz coverage were drawbacks of their new radio system implementations. Additionally, the cost associated with resolving these coverage problems was often brought forward as a negative point. Although coverage problems are not limited to the 800 MHz band, of late they are more visible because of the preponderance of 800 MHz system implementations. The following sections discuss system user and planner perspectives regarding the effects of terrain and the environment, and in-building coverage effects. Additionally, perspectives regarding the affects on "system cost related to coverage" are also discussed.

Terrain and Environment Characteristics. Coverage problems dominated the responses to the questions regarding operational effects at 800 MHz. Several system users indicated that their 800 MHz system, when constructed, had more dead spots than the previous system. Users also indicated that signal range is worse and is affected more by foliage and changes in terrain than had been the case with their previous systems. States and counties responded less favorably regarding coverage than did cities. The following comments reveal some of the coverage barriers associated with 800 MHz migration:

- A state system administrator was adamant that 800 MHz system tests indicated coverage problems in the mountainous and densely forested portions of the state. Because the agency's mission is to cover the entire state, and in some instances serve as a primary responder, this lack of coverage prevented them from moving to 800 MHz.

- A planner for a large county attempted to install an 800 MHz system using four existing tower locations. The system coverage was so poor that the county had to add four more sites to obtain adequate coverage.

- One representative attempted to dispel concerns regarding 800 MHz coverage by indicating that all of the previous systems had coverage problems as well. It is only because of the more capable 800 MHz radios that users can see that they are out of range. This creates the perception that there is a greater coverage problem than actually exists.

In-Building Characteristics. Perhaps the most significant coverage problems are experienced inside buildings. In many cases, it is necessary to maintain routine radio communications within a facility such as a jail or courthouse, or event-driven communications during times of emergency (e.g., evacuation or fire). Firefighters require extensive portable-to-portable coverage because most of their communications occur on scene at the emergency site. Firefighters frequently complained about in-building coverage afforded by their 800 MHz systems. The interviews also found system planners that specified precise coverage levels in specific buildings tended to have the most success with in-building coverage. The following perspectives provide further insight into in-building coverage at 800 MHz:

- One fire department official indicated that that in-building coverage was a severe limitation of his county's new 800 MHz system. The official attributes this problem to trunking and the repeating of 800 MHz channels. He notes that coverage problems are not experienced on the department's VHF channels which are not repeated.

- A system planner of a large fire department had expressed concerns with in-building coverage before moving to the 800 MHz band. However, the current system has not been as problematic as the previous system, and has yet to endanger any of the firefighters.

- Some systems planners indicated that they received surprisingly good coverage from their 800 MHz systems, including improved portable-to-portable coverage and in-building coverage.

Cost Characteristics. The interviews uncovered two major causes of cost concerns. First, the limited number of vendor choices dramatically increases system costs. Secondly, because the coverage area of 800 MHz is significantly less than at lower bands, radio infrastructure improvements must be made to increase coverage. Such infrastructure improvements are often expensive. Most respondents discussed the rather high costs of implementing an 800 MHz system, although many had anticipated those costs and planned accordingly. For those states, counties, and cities that had successful funding initiatives and long-range planning established, the costs tended to be in line with their expectations. Agencies and departments that chose not to move to 800 MHz systems stated that cost was the most significant factor. No mention was made that recurring costs or post-installation costs were a problem; however, most systems are still under warranty, and it may be too early to predict the consequences of recurring costs. The following points provide users perspectives regarding cost and 800 MHz systems:

- An interviewee whose state was considering a new LMR system stated that a cost analysis considered maintaining the current VHF system, upgrading the VHF system, and/or installing an 800 MHz system. The 800 MHz system would have cost more than six times as much as maintaining the current system, and about twice as much as upgrading the VHF systems.

- Another large state that is considering migrating to 800 MHz has shown that, because twice as much coverage can be obtained from a VHF system, migration costs could be halved by constructing a VHF system.

- The only planner who thought that the 800 MHz system cost less than expected believed that the vendor had consciously underbid the work to obtain business from neighboring jurisdictions. The vendor, the planner claimed, had taken several shortcuts that prevented the city from accepting the system.

- A participant from a large state now implementing a system referred to the installation costs of an 800 MHz system on a statewide scale as “outrageous.”

D.4.6 Operations

Performance is the key of any radio system’s effectiveness. With public safety systems, superior performance is critical. Strong operational performance can often mean the difference between life and death, causing radio operations to be among the most important issues deliberated about when decisions regarding new radio systems are made. For system planners to make informed decisions, it is critical to understand the operational impacts that users have experienced after implementing their 800 MHz systems. The following sections present overviews of commonly cited issues affecting the operations of 800 MHz systems.

Reliability. Reliability is perhaps the most critical operational component of a radio system for public safety use. A system whose performance is unreliable can lead, at the least, to dangerous operational scenarios, or worse, to scenarios that are deadly for public safety officials. To determine the relative reliability of the 800 MHz radio systems, interviewees were asked to compare the reliability of their previous radio system to that of their 800 MHz systems. Table D-4 shows the results.

Table D-4
Effects of 800 MHz System Use on Reliability

System Reliability	Number of Responses
Improved	17
Similar	5
Worsened	1
Unanswered	5

Most respondents indicated that their 800 MHz systems are or will be more reliable than their current or previous systems. The interviewees provided four reasons that 800 MHz networks are more reliable: the new systems are newer and more durable; 800 MHz users reported minimal down time; the systems are redundant and it now takes multiple failures to knock users off the systems; and specific design requirements were established and achieved.

Several respondents indicated that 800 MHz systems did not improve the reliability of their current or previous system, rather reliability was equivalent. These opinions were based on two issues. First, some respondents stated that the terrain and environment of system usage have had some limiting effects on coverage area. Secondly, a few participants claimed that user skepticism about computers running their communications system has affected the general perception of the 800 MHz system. The following comments are examples of the prevailing effects 800 MHz has had on system reliability:

- A planner for a large southwestern city indicated that the city's successful design implementation allowed for a network that has no single points of failure and usually requires three to four failures before a user is knocked off the system.

- A system administrator for a large city stated the city's 800 MHz system had successfully handled about 3 million calls per month with no problems. This many calls could never have been handled by the previous 30-year-old system.

- In a mid-size mid-western town, a planner indicated that the 800 MHz system was more reliable and credited this to the durability of the new equipment.

- An administrator for a small, densely populated metropolitan county stated that the county's 800 MHz system had failed only twice during the 5 years since implementation. The total down time has been only 39 seconds.

- A planner for a small southwestern town felt that the town's 800 MHz system was viewed as being only as reliable as their previous system because of problems arising from user anxiety over the complexity of the new system and stemming from the system's reliance on computers.

System Capacity. Many system users claimed to have experienced significant improvements in their radio system capacity, with greater ability to manage frequencies as a result of trunking at 800 MHz. One-user-per-channel capacity problems no longer bind public safety systems. With trunked 800 MHz systems, entities can create many talk groups with a set number of channels. Talk groups allow multiple groups operating independently of one another to communicate without interfering with separate groups' operations. The following are comments from individuals who have positive experiences with their system capacity:

- A planner for a mid-size western city stated that with the city's 800 MHz system, users receive far fewer busy signals and have had no problems with queuing on the 10-channel system.

- A system planner for a large southwestern city indicated that 7,500 units could be loaded on the city's 20-channel system running at approximately 40 percent usage with almost no blocks.

Education and Training. Many system users and administrators who had moved to 800 MHz systems identified education and training as a significant operational problem. Often, this was attributed to computerized technology so radically different from any previous radio technology that the learning curve is exceptionally steep. Others attributed it to an attitudinal problem, with users unwilling to give the new technology a chance. The following are examples of the effects 800 MHz systems have had on user training:

- A planner for a large pacific coast county stated that a definite learning curve is associated with 800 MHz usage. The delay in the press-to-talk feature, combined with other technologies that alter the quality of sound, further reinforce an already innate human instinct to resist change.

- An administrator for a large eastern state commented on the problem of education and training impeding the use of 800 MHz systems to their full potential, and how training brings officers off the streets when already too few are on the streets.

- A radio manager for a large metropolitan county stated that 800 MHz systems face a standard transitional problem in retraining their radio users. The county believes that these impacts are only temporary.

- A manager for a large mid-western state indicated that a critical element of the successful implementation of an 800 MHz system is to understand that 800 MHz radios are far more sophisticated than previous radios. For this reason, system planners must provide adequate education and training in the use of the radios.